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STRAITS SETTLEMENTS.

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OF THE

MALAY PENINSULA.

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It is proposed to publish from time to time, as occasion may serve, Bulletins on subjects connected with Agriculture and Horticulture in the Malay Peninsula. It is hoped that planters will send to the Director of the Botanic Gardens, Singapore, notes and observations on the cultivations of the various crops under their care. Observations on insect and fungus-pests are especially requested, and these should always be accompanied by specimens of the injurious insect or fungi either alive, or preserved in spirits, except in the case of butterflies and moths which should be sent dry in envelopes.

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SAGO.

The genus *Metroxylon*, to which the sago palms belong, contains about six species, which occur over the whole of the Malayan and Papuan regions as far as to the Fiji Islands. It belongs to the group of palms known as *Lepidocaryineæ*, distinguished from all other groups by the fruit being covered with scales. To the same group belong the rotans, *Dæmonorops*, *Calamus*, *Plectocomia*, etc., nearly all climbing palms; the Bertam, *Eugeissona*, the Salak *Zalacca*, stemless bushy palms, and the arborescent *Raphia*, from Madagascar, Africa and South America; *Mauritia* and *Lepidocarya*, from Brazil; and *Pigafetta* from the Moluccas and New Guinea.

Metroxylon is distinguished from all by its arborescent habit and erect terminal inflorescence.

Of the species described and named, most are very little known, and even our too common species have been much confused.

The following is a list of the species:—

M. Sagus, Rottb.—The smooth sago, occurs in the Malay Peninsula and Sumatra, and wild or cultivated as far as New Guinea.

M. Rumphii, Martius.—The spiny sago, possibly a native of the Malay Peninsula, but more likely introduced from the Moluccas or New Guinea.

M. longispina, Mart. } Three very little known plants, of which
M. micracantha, Bl. } Rumphius has published short notes. They
M. sylvestre, Mart. } inhabit Ceram, Amboina and other islands of the Moluccas.

M. vitiensis, Seem., and *M. amicorum* are natives of the Polynesian Islands. The seed of the latter species is imported into England as vegetable ivory.

None of these, however, have the value as flour-producers of the first two, although some at least produce a certain quantity of sago.

I cannot find that there is any difference in quality or quantity of sago produced between the smooth sago *M. sagus*, Rottb., and the spiny one *M. Rumphii*, but the former is more extensively cultivated in the Malay Peninsula, while in New Guinea and the adjacent islands, Beccari only saw the spiny kind, and Rumphius too, says that the spiny one was most common in Amboina in his day.

Mr. Bampfylde mentions three wild forms or species in Sarawak known as Pantu, Entibap, and Mudur. These grow in the interior on hilly ground, and are also, to some extent, planted by the inland tribe. The Entibap does not produce suckers, and it and the Pantu are remarkably beautiful palms.

Description.

M. sagus, Rottboel, Nye. K. Dansk vid. Skrift ii, 527.

M. inermis, Mart., Nat. Hist., Palm, iii, 215.

Sagus lævis, Rumph., Herb. Amboin., i, 76. Blume Rumphia, ii, 47 to 86. Jack's Malayan Miscellanies.

S. Koenigii, Griffith, Palms of British India, 19, 22 to 181.

S. inermis, Roxb., Flor. Brit. Ind. The description is too incomplete to be sure of the identification.

S. lævis, Griff., 4, 24 to 182, is based on an extract from Jack's Miscellanies, and is illustrated by a drawing of a piece of the inflorescence of *Zalacca conferta*.

The smooth sago is easily distinguished by the absence of spines on the leaf sheaths. The habit of growth is somewhat like that of the Nipa palm. From the side of the primary shoot prostrate rhizomes are emitted in every direction. They attain a length of six to eight feet and a thickness of one and-a-half, strongly marked with the rings whence leaves have fallen, and emitting copious stout roots from the underside. The roots are terminal or axillary and develop into stems about forty feet tall and a foot and-a-half through round grey, and bare of leaves when flowering for the greater part of their length. The leaves are about twenty feet long, the base very broad and sheathing with a papyraceous edge above nearly terete, about four inches through. There are sixty pairs of pinnæ, linear, acuminate three feet long and three inches across, dark green and stiff with a strong rib running down the centre. The inflorescence is terminal, very large, an erect branched panicle. The flowers are closely packed in cat-kin like spikes about six inches long and half-an-inch through. They are an inch and-a-half apart, and the internode is covered by a stiff dry acuminate bract, about two inches long. There is a short peduncle to the spikes about half-an-inch long, which springs from a notch in the rachis of the inflorescence. It is protected from injury by rain by a coating of soft red wool. The flowers are very numerous and small, sunk in the brown wool which covers the cup-shaped bracteoles surrounding them. There are also outer bracts broad, short and glabrous cartilaginous. The male and female flowers are irregularly mixed, the males being most abundant.

The male flowers are almost sessile, with three free obovate obtuse striate sepals, and three oblong obtuse cartiliginous petals, green or more commonly red and shining. The stamens are six but little longer than the petals; anthers curved linear, yellow, the filaments are oblong linear about as long as the anthers, deep green, connate at the base into a cup. The pistil is reduced to a small yellow subcylindric three lobed process, shorter than the filaments.

The female flower is very similar, but the stamens seem infertile, and the pistil consists of a cylindric ovary covered with large thin greenish scales, and terminated by three linear conic hard styles. The fruit is stated to take three years to ripen.

I have re-described this palm, common as it is, as its structure appears really to be little known, and specimens seem to have been rarely preserved in herbaria. Doubtless the reason for this is that the stems are always cut before flowering when the plant is cultivated, and as now, all the half wild patches of sago palm belong to some native, it is by no means easy to get flowering specimens. The plant described was cultivated in the Botanic Gardens.

M. Rumphii, Mart., Nat. Hist. Palm, iii., 213 & 102, 159.
Sagus Rumphii, Wild sp., pl. iv, 1-104.
S. genuina, Blume, Rumphia ii, 150.
S. farinifera, Gaertn, ii, 186 & 120 f. 3.

The tree much resembles that of the smooth sago, but appears to average on the whole a smaller size. The leaves are on the whole a little smaller, and on the leaf sheaths are transverse curved ridges of different sizes bearing long slender spines, the centre ones of each ridge being the longest and attaining a length of six inches above the sheath, the mid rib bears at intervals of six inches smaller crests about an inch long with short spines, arranged in a single row along the back of the midrib. The segments of the leaf are rather shorter than those of the smooth sago, but of about the same breadth.

The inflorescence somewhat resembles that of the smooth sago. The branches are from six to eight feet in length. The sheaths below them are provided with comb-like ridges of sharp but not very stiff brown spines about half-an-inch long. The spikes are about five inches long, and half-an-inch through, with rather stout peduncles nearly two inches long closely appressed to the main rachis, rounded on the outer and flattened on the inner surface. Two sheaths enwrap this peduncle, the outer one dry and brown, is armed with short brown spines irregularly scattered over it. It encloses not only the peduncle but the rachis of the inflorescence, and is terminated by a lanceolate limb about an inch long. The inner bract is much smaller, and opposite to the outer one lying between the peduncle and the rachis. It is dry and red with a short lanceolate limb, and provided as is the rachis at the same spot with a little red wool. The flower spikes are very dense with much less brown wool between the flowers than in the smooth sago. The bracts are ovate dark red and ribbed, the bracteoles are shorter and covered on the back with the yellowish brown wool.

The male flowers are $\frac{3}{16}$th of an inch long. The calyx is cup-shaped three-lobed, the lobes short and rounded, cartilaginous, green. Petals three, elliptic, obtuse, thickened at the points, green at the base, deep pink at the apex. Stamens six, their filaments are broad, deep green, connate in a ring at the base; anthers long, four-lobed, longer than the filaments, bright yellow. The rudimentary pistil of three very small terete pink processes.

The female flowers are much like the males, but the stamens are infertile, and the pistil is developed into a stout cylindric ovary covered with large soft green scales toothed at the edges, and terminated by the cartilaginous styles connate into a pink beak.

Mr. Bampfylde states that the spiny and smooth sago palms produce the same quantity and quality of sago, and that the plants grown from seeds of either kind taken from the same tree come up some spiny and others smooth, though suckers of either kind keep true, in which case the plants cannot be specifically distinct in spite of the differences in the flowers.

Distribution.

The sago palms grow in swampy wet spots on river banks and by the sea, on the borders of rice fields and in such like places generally in the low country. The smooth sago is cultivated and perhaps wild in Malacca, Johor, where at Batu Pahat and Pulau Kukub there are large plantations; in Singapore, and almost all

the islands in the neighbourhood, Sumatra, Borneo, Java and further east; and the spiny sago usually grows in the same places, but according to Beccari, the only sago in Amboina, Ceram, and New Guinea is the spiny one.

It has been introduced into many other colonies and other parts of the world, such as India, Ceylon, French Guyana and Martinique, but has, apparently, not met with much success in these places.

Mr. A. C. Bampfylde writes:—"Sarawak is the largest sago "producing country in the world. Sago flourishes as well in other "parts of Borneo, but is not so extensively cultivated as in Sara- "wak. Besides the Limbang near Brunei, the great sago pro- "ducing rivers lie between the Tanjong Kedurong and Tanjong "Lirik, viz., the Bintulu, Muka, Oya, Matu and the delta of the "Rejang. These rivers are inhabited near the coast by a race of "people known as Melanau, probably an aboriginal race, and they "have been great cultivators of the sago, whereas the Malays have "not gone in for the industry except, to a small extent, in the "Kalaka and other rivers."

The cultivation is largely on the increase and the Melanau people possess many square miles of sago plantations in the rivers above-mentioned, in which to some distance above the mouth little vegetation but this palm is to be seen.

The coast line between Kedurong and Sirik, a distance of 140 miles, is low lying and swampy with a rich alluvial soil upon which the sago palm best lives.

History.

The earliest mention of sago I have found is in Marco Polo's Travels, written in 1298. He met with it in the kingdom of Fanfur, apparently some part of Sumatra, probably, as Marsden suggests, Kampar.

Marco Polo's account is evidently that of an eye-witness and is accurate except that he states that the Natives make lances of the outer wood, which he says is very heavy and can be rendered so hard by fire that the lances will pierce any sort of armour, doubtless confusing this with the Nibong palm (*Oncosperma tigillaria*). He brought sago cakes home to Venice on his return.

Friar Odoric, who travelled in the East Indies in 1321 and later, gives also an account of it. He met with it in a place he calls Panten—"Near to this country (Java) is another which is called "Panten, but others call it Thalamasyn, the King whereof hath "many islands under him. Here be trees which produce flour."

His description is accurate, except that he says that the trees are cut into with an axe round about the foot of the stem so that a certain liquor flows out resembling size. He evidently saw the sago in course of washing and did not see the trees cut down, and probably misunderstood the account given by the Natives. Colonel Yule in the Hakluyt's Edition of Odoric's Travels suggests that the locality referred to might be Banjermasin, or else Panteh on the East Coast of Borneo. Since Odoric's time many accounts have been published, of which the best was that of Rumphius in the *Herbarium Amboinense* who is stated in the Cyclopædia of India to

have taught the Amboinese to separate the flour from the fibre. Accounts of interest have been also given by Valentyn, Crawfurd, Wallace, Forrest, Poivre, Dampier, and others.

Marco Polo brought the first specimens of sago-bread to Europe, but it does not appear to have been imported commercially till the nineteenth century. The Chinese invented pearl sago about 1815, and a small quantity of it found its way into the London market in 1818, and sold for thrice the price of ordinary sago (Crawfurd). It is said, however, in the Cyclopædia of India, that a woman from Bukit Batu in Siak, taught the invention to the Chinese.

I cannot find when sago was first imported into Europe, but from 1820 till 1825 the import into Singapore steadily increased from five thousand pikuls to twenty-five thousand; over-production then lowered the price, and the import lessened, but recovered in a few years, and increased so much that in 1842 nearly thirty thousand pikuls were exported from Singapore, which increased to nearly fifty thousand in 1847. Since then the demand has been tolerably steady, and the cultivation is at present slightly increasing.

Native Names.

The common Malay name for the plant is Rumbia, which name is in use in Malacca, Brunei, Java and Macassar, and Romibo is used in Banda.

Sagu is used all over the East for the product, and Rumphius gives Sagu Perampuan as a Malay name for the smooth sago. Sagu Dana is used in Bengal and Sagu Chawl in Hindu.

Sapia is used in Amboina, Sapia Molat being the smooth sago. Huda in Ternate, and Molong in Sarawak.

Chinese names are So-muh-mien, Sikuhmi and Kwang-lang-mien.

Cultivation.

The tree is usually propagated by offshoots which grow very readily, and branch rapidly. The seed in the Malay Peninsula seems nearly always undeveloped and is useless, but good seed is procurable at Siak in Sumatra and Borneo, and according to Rumphius is good in the Moluccas. Seed when sown should be planted in its husk just beneath the soil and protected from too heavy rain. It usually germinates rapidly, and should be shaded from the sun till the plant bears three leaves, and is strong enough for planting out. The cuttings are taken from the root-stock of older plants when about six inches tall, and may be at once planted out, only requiring shading at first if the spot is very hot.

The palm is always grown in wet soil, such as borders of rice fields, and open swamps. The plants should be planted about twenty-feet apart. They branch soon, and eventually form often a dense, almost impenetrable thicket, sometimes choking up the watercourses.

After once planting they require no care except to prevent injury from fire, if there is much grass around them, and to guard against beetles. The common black coco-nut beetle (*Oryctes rhinoceros*) attacks the younger shoots in the same way as it attacks the coco-

nut trees, and often destroys them, but ordinary care in keeping no rubbish about in which it can lay its eggs will prevent its doing much harm, and it is not nearly as destructive to the sago as to the coco-nut. Rumphius figures and describes a black palm-weevil (perhaps *Rhyncophorus ferrugineus*) as attacking the spiny sago, but this species does little or no harm to the tree here.*

The stems grow very slowly, taking upwards of twenty years to develop at first, but as the plant gets older, they appear to grow more rapidly; and in a large plantation there are always some stems ready to cut. The stems are cut before the appearance of the flower shoot, that is to say, when they are about forty or fifty feet tall. The stems are then felled, and cut up into pieces about four feet long, or split in two according to the method of preparation in use.

Methods of Preparation.

Chinese.—The tree, if a full sized one, is split longitudinally with an axe; if smaller, it is cut into pieces about six feet in length, and the outer bark and woody portion removed. It is then scraped with a board about three feet long studded with nails driven half way through and with a handle at each end.

One man takes each end of the scraper and working it backwards and forwards scrapes the pith into small bits. The pith is put to soak in water in a wooden tub for two days, the water being changed at intervals. The fibre and cellular tissue floats to the top and can be easily removed, and the sago sinks to the bottom in the form of a white powder. This is taken out of the tub and put to dry on trays in the sun, the trays being supported usually on trestles made of the outer woody part of the tree. It is then packed in bags lined with leaves and sent to the sago factory.

The Chinese usually move about the country with their apparatus, and buy up the stems as they stand from the Malay owners, wherever they can find them.

Another method in use by the Chinese in Singapore is a modification of the Bornean method. The sago is put into a square mat made of split bamboo with a rattan edge, and at each of the four corners is a rattan ring. This is laid over a square wooden frame the bottom of which is made of boards with narrow spaces between. Water is poured on the sago and two men each holding two corners of the mat in their hands trample about in the sago, shaking it at the same time by raising and lowering the sides of the mat. The flour washes through the mat and passes down into a wooden trough about six or eight inches wide and about as deep. It is divided into three or more compartments and often one is put at right angles to another, so that the water can run slowly and deposit the flour. This seems a very wasteful method, as much of the flour evidently remained, after the washing, in the refuse, and apparently a good deal was carried off by the water and not depo-

* The beetle does not attack the trees in Borneo according to Mr. Bampfylde, but there is a disease known as "Bungas" by the Malays and "Nawai" by the Melanaus. It does not, however, attack the tree till it has reached maturity and is then easily detected, and the tree can be felled and used ere any harm is done.

sited in the troughs. The water used for washing in the factory I examined, was thick and dirty, and the flour produced was by no means clean and white.

In Johor, at Tanjong Kopang, I saw a Malay washing the fresh scraped pith through a bamboo mat, in a somewhat similar manner, except that he did not shake the mat but merely kicked the pith about with his feet; the framework on which the mat lay was fixed over a boat, supported by posts, probably a survival of the Bornean custom of washing the sago in boats on the river. In this case also the water used was by no means clean being derived from a stream running through a swamp.

Papuan method.—The natives of New Guinea use for cutting up the sago pith an instrument composed of a conical piece of flinty stone excavated at the broad end and fixed by the narrow end into a joint of bamboo which is fixed to a wooden handle like an adze. In Ternate the stone is not used, but the sharp edge of the bamboo itself is used to cut the pith (Beccari). In Ceram (according to Wallace) a club of hard and heavy wood is used with a piece of sharp quartz rock firmly imbedded in the blunt end and projecting about half an inch. The pith is cut into strips, and then taken off to wash. The washing troughs are made from the sheathing leaf-bases and the fibrous coverings of the base of the leaf of the cocoanut is used as a strainer.

The Malay in Singapore uses an adze-shaped axe made of Nibong wood (*Oncosperma tigillaria*, Griff.) with which after cutting the tree into pieces with a chopper and splitting or barking it, he chops the pith into very small bits.

Imported Sago.

The raw sago is often imported into Singapore in a very rough state containing much fibre and water, sometimes as much as 45 per cent., and it is valued according to the amount of this rubbish, that is, according to the amount of washing it has undergone. It appears to be seldom, if ever, adulterated by the natives, but the dealers sometimes add tapioca flour to it.

Good sago should be white and clean, though a pale pink colour is not objected to. A strong flour, says Mr. Earle, that is, one strong in starch, always commands a premium, in fact the stronger the flour the better it is liked, but it must be thoroughly clean; that is to say, the manufacturer must aim at getting the flour not only free from the fibre but also from the cellular tissue, in which during life the starch grains are retained.

The best sago is made in Singapore, because the water used is better. Native washers, however, I have seen using dirty muddy water, and taking no pains to keep the troughs covered, or to clean them out. This must deteriorate the value of the product, and it would be in most places easy to procure a good supply of clean water by which the sago could be made perfectly white. In badly washed sago one often sees black stains, due to the evolution of sulphuretted hydrogen. This appears to be the result of decomposition of the cellular pith-tissue which has not been properly washed out. As the sago dries, this discoloration disappears, at least

to a large extent, but the pithy cells remain and give the flour a lower value. Most of this pithy matter is of course sifted out by the use of very fine boulting cloths, and the remainder should be floated away in the water, as the starch is much heavier and sinks first leaving the light pith in the water.

Most of the sago imported from the Karimun Islands, Siak, Banda, Dayak, and other small islands in the vicinity, as well as Macassar, Coti, Pacatan, and Amboina come in unwashed, and after washing in Singapore is sold under the name of No. 1 and No. 2 Singapore Sago. That from the first-mentioned places is white and fairly strong, but that from Macassar and the Eastern Islands varies from pale pink to white and much stronger. The reason given is that the palms on the islands near Singapore are not allowed to mature and so the sago is whiter and less strong than that of Macassar, etc., where the palms are allowed to grow old before cutting, but as according to Beccari, the only palm in this Eastern region is the spiny one, and the plant grows to a very large extent at least round Singapore is the smooth one, it seems likely that the difference is due to the flours being derived from different species of trees.

Sago Flour.

The sago comes into Singapore in the form of a dirty white clayey mass, in gunny bags lined with leaves of the sago palm. It is often blackened by the evolution of sulphuretted hydrogen and the decomposition of the pith cells remaining in it. The factories are situated at some distance from town, on account of the bad odour produced by the sulphuretted hydrogen, and generally on the bank of a river, so that boats can readily come up to the factory. It is piled up in a shed, and dug out with a *changkol* when required for washing. There are a number of wooden tubs about four feet tall and four and-a-half across, over which a boulting cloth is fastened by strings at the four corners. The raw sago is put into the cloth and washed and rubbed. From the first washing the first quality of sago is obtained. When dry this is of a pure white starch, with a smooth silky feel, giving a squeaking noise when rubbed between the finger and thumb. Under the microscope it appears to consist entirely of starch granules quite free from any pith-cells or fibrous matter. The refuse which does not pass through the boulter, is of a light brownish colour. It is transferred to another tub and washed again as before, and what passes through the cloth is second quality sago. This is dirtier in colour than the first quality and rougher to the feel, containing a considerable admixture of pith-cells. The refuse from this washing is washed again for third quality sago and what remains is usually thrown away or used to feed pigs.

The flour thus prepared is allowed to dry and packed for shipment, or made into granulated or pearl sago. Sarawak flour is quoted in the market reports at $2.45 per pikul, and that of Brunei at $2.17.

Granulated Sago is made by mixing the flour with water and rubbing it through sieves, and after shaking it in a cloth so as to

make it into grains, it is dried in the sun or in an oven at 140° of heat, or in a pan over the fire. Granulated sago keeps better than sago flour and is easier handled, so that it is the most convenient form for export. It is usually sorted according to the size of the granules.

Pearl Sago.—The flour in a damp condition is squeezed through a cloth into a sieve perforated with holes of the required size from which it falls into a shallow iron pan over a fire. The pan is previously rubbed with the vegetable tallow known as Minyak Tengkawang or Sangkawang, the produce of *Diplocnemia sebifera, Pierre*, a laurineous tree from Borneo.

Pearl Sago is quoted in the markets at $3.40 a pikul.

Uses of Sago.

The flour is used extensively for starch, and in the manufacture of chocolate, also together with the granulated and pearl sagos, for puddings, biscuits, &c. It is sometimes used for adulterating wheat flour.

It appears to be still largely used as food by the natives of the Eastern islands, but is seldom eaten to any extent by the natives of the Malay Peninsula or the Western islands, except in times of scarcity of the rice crop. The manufacture of sago bread by the natives of the Moluccas has been described by Forrest and others.

Adulterations.

It does not appear that sago is often adulterated by the natives or manufacturers, but the cheaper tapioca flour may sometimes be used to adulterate it. This can be detected by the microscope, the difference in the form of the starch grains being sufficient to distinguish the two.

Other Uses of the Plant.

The leaves of sago make the best roofing attaps of any palm, lasting much longer than any other, and therefore are much in request. The pith of the leaf stalk is very suitable for insect boxes and might be used for pith hats and any such purpose. The stalks should be taken when full-grown, cut into lengths of about five feet and dried. The outer bark is then cut off with a sharp knife and the pith cut into slices of the required thickness. It is more satisfactory for insect boxes than cork, as it holds the pins better, and is more homogeneous, but unless the pith be thoroughly dried it appears to give out sulphuretted hydrogen in damp matter, though in very slight quantity, which has the effect of rusting the pins. This will probably not happen in dryer countries.

The leaf stalks are used in Borneo for making houses.

Other Sago-producing Plants.

The Kabong palm (*Arenga saccharifera*, Lab.) produces a sago which is said to be of very good quality. It is made in Java, but apparently is not used anywhere in the Peninsula.

Another Arenga (*A Listeri*, Hansl.) a native of Christmas Island, produces a beautiful sago, and is used by the inhabitants of that

island. The plant, though fairly abundant there, is peculiar to that locality, so that its flour has never come into the market. It is rather a slender tall tree with a grey stem, somewhat resembling the wild Kabong (*A. obtusifolia*) of the Malay Peninsula.

Sago Cultivation for Profit.

Sago cannot compete for use as a food stuff with wheat or the other cereals, for many obvious reasons, but it will always be a product of great value, not only as a food stuff but also for starch.

The little expense incurred in cultivating and preparing it, will go far in its favour, and the increased attention which is being paid to it and the larger supplies which are coming into the market show that the demand for it is steadily rising.

Many marshy lands which are otherwise only useful for paddy cultivation, and especially tidal river banks might with advantage be put under sago. The cost is comparatively small, and the crop though slow in coming at first, should eventually be a permanent source of revenue.

In countries also where for any reason periodical times of scarcity occur, this palm should be planted and its growth encouraged. Governments could, for instance, plant up the river banks and wet uncultivated spots, and with no further attention the trees would develop, and in a few years form dense thickets. The stems when full grown could be leased, and would themselves form a source of revenue, while in cases of scarcity of food, whether from failure of other crops, or blockades, or other such causes, a food supply of great value would be at hand to supply the deficiency.

Produce.

The actual produce of a plantation for the whole length of its life is not very easy to estimate without actual experiment, but the following notes may give an idea of its possibilities :—Suppose the young trees are planted at a distance of 12 feet apart, this would give 300 plants to the acre. They would be fit for cutting in twelve or thirteen years, meanwhile throwing out numerous suckers. The first crop would be 300 stems which may be valued at 300 dollars. The number of stems given would increase yearly till the maximum amount which the space would bear. I have seen as many as six stems in twelve square yards, but this may be considered as exceptional. Estimated at only half of this, say one to every four square yards, this gives 1,240 to the acre per year, which should give the same number of dollars. The plantation if well cared for should last for forty years, so that the return of a plantation may be looked as very remunerative for the expenditure it requires. It must be remembered, however, that the first crop is not reaped till ten or twelve years at least after planting.

Expenditure for one acre:—

300 suckers at 10 cents each, - - - -	$30
Cleaning, protecting, &c. for 40 years, say -	400
	$430

Produce for say 30 years :—

Say 30,000 stems at one dollar a stem, - - $30,000

A full sized tree will give a pikul of sago* when washed out which is valued at from two to three dollars, so that an acre when in full bearing, with 1,240 stems a year upon it, will give $3,100 a year or more.

But according to many writers this is much under-estimated. Forrest states that the average produce of a Molucca tree is 336 pounds, Rumphius gives it as 600 to 800 pounds, and good Sumatra trees are stated to give 760 to 950 pounds, and the worst 475. Presumably these weights refer to imperfectly washed sago. The Editor of the Cyclopædia of India points out that three trees will give more nourishment than an acre of wheat, and six more than an acre of potatoes, and an acre of sago will yield as much flour as 163 acres of wheat. Thus sago gives a larger value in nutriment per acre than any other plant in the world.

Trade.

By far the greater part of the sago imported into Europe, America and Australia passes through Singapore, and as of this a considerable proportion is prepared here, the trade is one of some importance.

The following statistics are taken from official reports, and show the rise in the amount exported :—

In 1830, the import into England was			2,688 pikuls.
1841,	„	„	45,747 „
1850,	„	„	80,640 „
1860,	„	„	161,123 „
1870,	„	„	250,919 „
1875,	„	„	332,880 „

almost all of this came from Singapore.

Since then the demand has risen higher and the amount brought into the market from Borneo alone this year, seems likely to prove larger than ever.

The import into Singapore for the last few years has been as follows :—

	Flour.	*Pearl.*
1887, - - -	Pls. 331,913	Pls. 109,805
1888, - - -	„ 455,018	„ 51,811
1889, - - -	„ 314,898	„ 78,665
1890, - - -	„ 374,441	„ 151,607
1891, - - -	„ 588,525	„ 73,170

The following table for the last six years gives the value in dollars of the imports into the various countries which use it :—

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* Mr. Wise tells me that in Borneo at Gaya, a stem will give as much as five pikuls,

Sago Flour.

	Great Britain.	U. S. America.	Germany.	Italy.	Australia.	India.
	$	$	$	$	$	$
1887	610,240	55,168	5,017	6,600	2,064	15,116
1888	981,397	67,377	13,154	70,533	1,523	8,880
1889	1,192,106	95,142	8,894	123,262	2,238	21,780
1890	794,162	68,768	17,975	26,045	3,015	4,034
1891	1,251,494	49,515	10,627	144,913	2,816	20,028
1892	1,579,727	112,193	11,690	224,638	3,085	42,389
1893	1,559,922	93,538	21,360	260,530	2,402	22,345
			Pearl.			
1887	186,196	...	75,041	...	2,093	27,013
1888	106,022	...	11,263	...	2,921	36,734
1889	160,286	...	50,167	...	2,895	14,782
1890	334,110	...	94,483		2,546	65,266
1891	105,287	...	41,106	...	618	38,463
1892	199,284	3,246	137,361	...	2,421	36,608
1893	184,329	2,680	98,977	...	907	32,017

Thus the British Islands take far the largest amount, and like all other countries but Germany and India take more flour than pearl sago.

Notes on Soils and Lalang-grass.

The following notes, though based to a large extent on observations made in Singapore, are applicable to a considerable portion of the Malay Peninsula, which is composed of the same class of rocks, and is subject to the same climatic and meteorological actions. The causes of the marked deterioration of soil after the destruction of the forests and the action of the lalang-grass (*Imperata cylindrica*) and of tapioca cultivation are, perhaps, the most important points to be investigated, and to study these thoroughly a series of analyses of soils and of products is essential. These experiments must be carried out when opportunity occurs.

When the island of Singapore was first taken over by the British Government, it was densely wooded all over with big timber, but much of this was felled, and the ground cultivated with pepper or gambier, and this again was abandoned. Now when the island is viewed from one of the taller hills, one notices that a considerable portion of it is covered with the grass known as Lalang, to the exclusion of almost every other plant. Nor do any other plants appear to be able to make any headway against this grass. Hills that were covered with lalang many years ago, are still covered with it. Lalang country too has a very bad reputation as being quite worthless for cultivation and yet this same land formerly bore a thick and luxuriant forest of huge trees, and smaller shrubs and bushes, which will no longer grow there.

What is the cause of this deterioration of the soil? Some persons have suggested that the roots of the lalang leave a poisonous product in the soil. This, however, has never been proved to occur in any plant, and there is certainly no evidence that such has happened here. On the other hand, I venture to think that the main cause of the injury is of a much simpler nature.

To understand this it is necessary first to examine the soil of a lalang field and compare it with that of an untouched forest.

The rocks of Singapore consist of ferruginous clays, gravels and sands, with here and there masses of hard ferruginous claystone and veins of nearly pure peroxide of iron, and in some places pure white quartz, gravels and sands and pipe clay. These all appear to be derived from the decomposition of the granite which forms the greater portion of the mountains of the Peninsula, and which crops up at Bukit Timah, Pulau Ubin and in a few other places in Singapore. Over these in the forest lies usually a thin rarely a thick layer of vegetable mould, the result of the decaying vegetation, the recently fallen leaves and sticks lying, partially rotten, upon the mould. Where the sub-soil is clayey there are many tunnels and passages of clay made by the termites (commonly called white ants) beneath the fallen vegetable debris, and the mould is not very deep. In very damp or sandy forest, or where the ground is rocky there are a few subterranean termites and the mould is often rich and deep.

In country that has been cleared and cultivated and then abandoned, the lalang-grass grows rapidly, and if the soil is dry and clayey it is soon covered with it. Such ground rarely bears any mould; the stiff yellow clay is quite bare. On the other hand, in the valleys between the hills, where the ground is damp, lalang is, as a rule, absent, and there is usually a thick layer of black or brown mould full of decayed vegetable remains.

Lalang Soil.

When a piece of forest land is to be cleared for planting, the trees are felled, left to dry a little on the ground and then ignited. After being burnt, a good deal of the lighter ash is blown away by the wind, and is washed away by the first rainfall. The rest is dug into the ground, and gambier or pepper is planted; little or no manure of any kind is supplied, though cut lalang or used gambier leaves are sometimes put over the roots of the pepper, and after a varying number of years the land is abandoned, and is speedily covered with lalang. The original humus of the forest has been washed away by rain, and the great drain on the fertility of the soil due to the cutting of the gambier twigs and leaves has not been compensated for by manuring. The ground remains a stiff yellow infertile clay, in that state capable only of growing lalang, which plant also prevents, as will be shown, the growth of any other plant upon it.

After the ground is first cleared, the plants that come up for the first year are relics of the original flora, many stumps throw up shoots again and seeds lying hid in the ground germinate. As the

ground is weeded and the cultivation continues these native plants become fewer and fewer, till after three or four years, only introduced weeds, lalang and bracken appear. Most of these weeds have plumed or light seeds which are drifted on to the land by the wind, or adhesive seeds which are brought in on the clothing of the natives.

The lalang grows very fast and soon chokes the smaller plants. When it has become very thick, say in about three months, it is very liable to take fire, and the natives frequently ignite it by carelessness or intentionally, sometimes to find the boundary stones of their holdings, which the grass has concealed, or to drive out game, or to obtain ash or charcoal for manuring the pepper from any old stumps or logs which may be left from the original clearing, or again to obtain the plumed seeds of the lalang, which flowers and fruits directly after it has been burnt; the plumes being used for stuffing pillows.

During dry hot weather the grass burns very rapidly and the fire may run over a large tract of country, destroying in its course any secondary jungle in its way, and often eating into primeval forest. Though the thick woods will not take fire and burn, still when a big grass-fire reaches it many of the trees and shrubs on the edge are destroyed, the grass springs up in their place, and in this way by repeated fires the jungle is destroyed.

On hills and slopes which have been thus repeatedly burnt, hardly a jungle plant except the lalang is to be found, but if the grass is not burnt, in many cases the secondary jungle may spring up. This is especially the case in small tracts of lalang where there are in the neighbourhood plenty of trees to produce seed and to encourage birds and fruit-bats to bring seed from elsewhere.

The secondary jungle consists usually of the following trees and shrubs:—

Melastoma polyanthum.
Vitex.
Adinandra dumosa.
Macaranga javanica.
Mussoenda glabra.
Ficus alba.
F. chrysocarpa.
Timonius jambosella.
Archytea Vaklii.

If all goes well and this is not burnt, it is eventually replaced by bigger trees, and finally will probably become high and dense jungle, humus is again formed and the soil becomes fertile.

Now, as long as the lalang remains all over the ground little or no humus forms, the ground remains a stiff hard yellow clay, and it is noticeable that the irregularities of the surface are smoothed and rounded, and sometimes covered with a thin ferruginous coating.* Exactly similar surfaces are to be seen in places where water has been constantly running over a clay soil.

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* This crust seems to be produced by the action of a slender thread like Alga, apparently allied to Guillanella which causes the formation of similar ironpan in Europe.

In fact the cause of the sterility of the lalang field is to be sought in the effect of the rain on the exposed slopes covered with the grass.

The *Rainfall* in Singapore averages 100 inches a year, that is to say, that the area of the island being 200 square miles, twelve hundred and eighty million tons of water fall on the island during the year.

When rain falls upon forest land, the drops are broken up by the leaves, a great quantity is immediately re-vaporised, and is absorbed by the leaves, and what reaches the ground is to a very large extent absorbed by the humus and sinks into the soil. The result of this is that there is little denudation at work in the forests, and owing to their humidity the growth of the plants is very rapid, and consequently the amount of humus is being constantly increased by the decay of fallen leaves and sticks.

In a lalang field matters are quite different. Such humus as might be formed by the decay of the leaf blades is very scanty; a good deal is removed by the termites, and the heavy rainfall washes away the rest as fast as it is formed. The leaf blades of the lalang, unless very long, stand quite erect, and the rain in falling on them pours down in an unbroken stream and strikes the ground with almost as much force as if the ground was bare. In a heavy storm the raindrops falling on an open space strikes with such force as not only to splash about in all directions, but even throw to a distance small fragments of earth and stone. Instead of being absorbed by the soil, the rain rushes down the slopes between the tufts of lalang, sweeping before it all the decaying vegetable matter. The loss of valuable salts by the drainage waters which percolate through the soil, must also be very large in the open lalang fields, inasmuch as the amount of water absorbed by the grass must be very small in comparison with that absorbed by the shrubs and trees of the forest. The expulsion of soluble salts (chlorides and nitrates of sodium and calcium) takes place most freely, says Mr. Fream (Elements of Agriculture, p. 23), when the percolation of moisture is most rapid, so that a heavy rainfall restricted to a few days does more harm in washing the soil than would the same amount of rainfall spread over a month; and if in England with a comparatively small rainfall, this loss is considered one of considerable importance, what must be the loss here where not only is the fall very much larger, but the violence of the rush of water is at times something extraordinary.

During the hot part of the day the forest soil remains damp and cool, but in a lalang field the temperature is very high, and the soil is baked into a firm hard crust. The rush of the rain over this alternating with spells of great heat and dryness gives the upper layer a smooth compact surface. Should seeds of any other plants fall among the lalang, the first rain shower sweeps them away, or they are killed by the rapid evaporation. I have often noticed in a lalang field that where the ground is broken and there are cracks, where there is no rush of water, and there is less loss by evaporation, seedlings of other plants, young ferns and the like soon appear, while on the flat smooth grass-covered surface these are quite absent.

Near the foot of Bukit Timah hill is a patch of bare soil with absolutely no vegetation upon it. Here and there in deep cracks the common Resam fern (*Gleichenia*), which is abundant all round the spot, has attempted to push its way, but maintains a precarious existence. Not even can the lalang grow here. The ground was apparently dug away to supply clay for the road at some time and has remained ever since, for at least six years, entirely bare of vegetation. The rush of water sweeps away every particle of humus and any seeds which may fall on it from the neighbouring high forests. After heavy rain frequently an extensive series of earth pillars about six inches in height or less can be seen. These are formed by the washing away of the soil, except where small pebbles lying upon the ground shelter the earth below from the force of the vertical rain. This serves as an illustration of the astonishing force with which a tropical rain strikes the ground and the enormous resultant denudation.

Humus producing Animals.

Earthworms.—The important action of earthworms on the soil has been the subject of a well known work by Darwin, who has shown how they periodically turn over and expose the mould to the air and sift it so that no stones larger than the particles they can swallow are left there. Bones, remains of insects, twigs, &c. are buried by them; the leaves are partially digested, saturated with their excreta and formed into humus. Singapore is not absolutely unprovided with earthworms, but in comparison with England they are exceedingly scarce. In fact, one may safely say that in the greater part of the soil of Singapore they are utterly absent. They occur here in damp soil under trees, in manure and decaying vegetable matter, such as rotten saw-dust and tan-bark, and sometimes but rarely in jungle soil.

The reasons for their scarcity are two. In the first place, the heat of the sun and the dryness of the soil in many places is quickly fatal to them. A worm taken from its burrow and held in the hand for a few minutes is killed. Darwin shews that in long continued dry weather in Europe they burrow very deeply, to avoid the effects of drought, but here where the heat is so much greater, and the soil in exposed places is dry and hot for a much greater depth than can ever occur in Europe, it is impossible for worms to come to the surface at all.

Furthermore the excessive rainfall would, except in a few places, flood their burrows, and would prove fatal to them.

The effects of heat and rain upon them is well shown, by the fact that beneath garden seats which have remained for some time on the turf in open parts of the garden there is often a thick deposit of worm castings, and the improved appearance of the grass partly, no doubt, from the mere shading of the runners, as described later, but partly also from the turning over of the soil and the formation of humus by the worms is very striking.

In the low valley lands where the soil is much richer and damper than the rain-washed slopes above, one would expect worms to be

abundant, but for some reasons they are very rare or absent. I am inclined to believe that this is due rather to the saturation of these places with water after heavy rain.

In the hot dry lalang fields one would not expect to find worms, and in the greater part of this class of country they are entirely absent, but I was rather surprised in passing through a lalang field near Ang Mo Kio, to find the ground to be quite damp and covered with a thin layer of worm castings. The grass growing here was very thick and what was unusual, there was a considerable quantity of a kind of yellow vetch (*Crotalaria alata*) growing up through it, shewing that the soil beneath was richer than one usually finds in such places.

But besides climatic difficulties with which earthworms have to contend, there is that of the competition of the termites, commonly known as white ants. There are a large number of species of these insects, but only one or two seem to play any important part in the matter of the formation or destruction of soils, viz., the species which habitually dwell under ground. They compete with the worms in securing for food such vegetable matter as is thrown upon the ground. If a pile of cow manure is put down in ground containing earthworms, these animals quickly find their way into it, but at the same time armies of termites attack it, and if it is not too large carry it completely away in an incredibly short time. The termites not only work faster than the worms, but are so much more abundant that the latter cannot compete with them on equal terms.

But in many places termites do not live, because the soil is not suited for their nests. The domed cells requisite for the colony can only be made in clay and in dry spots, so that in sandy soils and the damp earth of the valleys these animals do not occur; and it is in spots where the termites are absent that one finds the greatest number of worms.

Ants.—The effect of the action of ants upon the vegetable world has as yet been but partially studied, one of the most important works performed by them is that of conveying soil from the ground to the ferns, orchids and other epiphytic plants on the trees. There can be no doubt but that a large number of epiphytes are modified so as to encourage the ants to bring them soil, and to retain it when brought. One of the best examples is that of *Platycerium grande*, the elk's horn fern, which has in addition to its long thin much branched sterile fronds, and the shorter and thicker kidney-shaped ones which bear the sporanges, a number of erect stiff broad ones which serve to retain the soil brought up by the ants for their nests. Similar fronds are borne also by Drynaria. The amount of soil deposited by the ants in the leaves of a large specimen is very great, and really consists of rich humus carefully collected by the ants.

But some species of ants play an important part also in turning over the soil on the ground very much after the manner of the common English ants. The chief of these is a long slender blackish grey species which appears to live almost exclusively on fruits and it can often be seen carrying the small berries of the Tembusu (*Fagræa fragrans*) to its burrows. These burrows are usually made

in grass plats and descend vertically for some distance.

The ants constantly bring up a fine grey earth in pellets and pile it up round the mouth of the nest where in lapse of time it becomes spread over the whole adjoining surface, and seems to much improve the herbage around.

The number of ants in each nest is apparently small, some two or three dozen, and though the nests are abundant in suitable places, yet, owing to the small extent of turf wherein they mostly live, the general result is on too small a scale to make any great alteration in the soil of any district.

Termites or White Ants.—That these animals play a most important part in the making or destruction of soil, there can be little doubt, but partly from their habits of working exclusively in the dark. Very little is known about them. Mr. Drummond, in "Tropical Africa" has shown that in some places they bring up great quantities of the deeper soil to the surface to make their elevated nests so that "there is so to speak a constant circulation of earth in the tropics."

But this is evidently not the case here, and I am inclined to think that their action is injurious to the soil rather than useful. There are a considerable number of species in Singapore, and probably most of these are undescribed, but the only species which really appear to affect the formation of soil, are two which live in the clayey soil entirely under ground. Both probably belong to the genus *Termes*. One is exceedingly common and well known, building subterranean nests of several chambers, of no great size, in grassy or shaded spots, or again in open lalang fields, if there is enough nourishment for them, and for want of a scientific name may be called the common ground termite. The other, a much larger species, makes somewhat similar nests of very large size, many yards in circumference, and often elevated into large mounds. This especially frequents lalang fields but is much less abundant.

The common ground termite, though its nest is subterranean, does throw up at times a mound of soil about four or five inches high, apparently merely to get rid of the clay taken from the subterranean chambers. The mound thus, from its quality and quantity, for but in few nests is it thrown up, is really valueless for fertilizing the soil, so that in this way the termite here is not as beneficial as that of South Africa is said to be. The nest when opened is seen to consist of a variable number of connected chambers, four or five inches across, domed and perfectly smooth inside. these are built from six inches to a foot below the surface. In most of these are masses of a brown earthy substance arranged in thin plates connected together in an irregular way by their edges. These are the fungus gardens. Dotted all over them are small white balls of the mycelium of some fungus, the threads of which permeate and run over the rest of the walls. These fungi are the food of the larval termite. Besides the extensive fungus gardens there are small nurseries in which the eggs laid by the queen are put to hatch, and towards the centre is a compact mass of yellow stiff clay about as big as the palm of the hand, more or less oval in the outline, and flattened, and in a shallow cell in the centre of this

lives the large queen or fertile female with a small male. The remaining inhabitants of the nest are the workers, very numerous, who build up the chambers, and make the fungus gardens; the soldiers, much fewer, larger, with big heads and powerful jaws, whose function is to protect the nest from the attacks of enemies.

When the termites attack a piece of wood, they generally began from beneath and remove it piecemeal, replacing the tissue if necessary or covering it up entirely with clay from below the ground. Dead leaves, masses of cow dung, or manure rich in vegetable matter are treated in the same way. The wood, etc. is either eaten on the spot, or carried down into the subterranean chambers, where often a quantity can be found stored up. The termites pass their excreta in a semi-liquid form, and with this they build up the fungus gardens. The decaying vegetable remains, which should have been converted into mould, are thus removed from the surface of the soil and stored up under ground in domed cells where it is practically out of reach of the roots of the plants. What eventually becomes of it?

When an abandoned nest is opened one finds that the fungus gardens are almost or entirely gone. They are partially soluble in water and are probally washed out with the drainage water. A portion was put in water and left for some time, the water became of a bright yellow colour, and the more insoluble portions of the substance were converted into a flocculent mass which eventually putrified exhaling a fœtid odour.

Direct action of termites on living plants.—Though this has little connection with the formation of soil, I will make a few remarks on it here, in the hope of eliciting information on the subject from accurate observers.

One constantly hears of coffee and other trees being destroyed by termites, and the informants seem to think that the insects absolutely eat the roots and base of the stem of the living tree and so destroy it. I have great doubts of this. In opening termite nests, I have often seen roots of trees and other plants traversing the middle of the buildings and surrounded by working termites, but these, if large, are carefully walled over with clay and even the bark is absolutely untouched though the termites were fetching food supplies from a considerable distance. In one case the termites had thrown up galleries against a tree on which an orchid (*Renanthera alba*) was growing, the soft roots of which pushed their way through cracks in the clay crust and traversed the passages, but there was not the slightest mark of nibbling on the roots, which were perfectly healthy.

Frequently, however, the termites throw up galleries along the trunk of a tree usually so induced by a dead bough higher up, and if the bark is rough and corky, they will cut away a great deal of the bark and in this way sometimes expose the cambuim layer or cut down nearly to it so that the rain and sun kill the living part of the tree at this point, and as the wood dies away the termites cut away more and more, and so by letting the wood suffer from exposure injure or kill the tree. But this is rare, and almost invariably occurs in trees dying from other causes.

In the Malacca Garden, a fine young clove tree loaded with young fruit suddenly died, and this was said to be due to direct attacks of termites, on examining it, the most conspicuous feature was the mass of termite galleries thrown up all round the base of the tree, and it appeared as if the attack of these insects cutting off the bark all round had been the cause of death. But on digging away this surrounding soil it was discovered that the base of the stem, had been severely attacked by a fungus, the whole of the bark above the roots being black and putrid, while some of the larger roots were covered with a white mildew. The tree must have been fatally attacked by the disease some days previously, at least, and as soon as the fungus had practically killed it, the termites threw up their galleries and began to destroy the dead parts of the tree, several trees had thus perished, and on similar ground at a little distance a plantation of castor oil had perished, suddenly, the destruction being attributed to termites, but being rather, I imagine, due to the hardness of the soil, which was unsuited to the cultivation.

Two Araucarias were some years ago planted beneath two very large trees, the roots of which so permeated the soil in every direction that even grass would not grow beneath them, the ground being full of roots. The Araucarias grew to about fifteen feet tall, and then they were attacked by termites which constantly covered their bases with clay, beneath which they cut away the bark; eventually both trees died, and it was found that beneath each was a nest, and that the termites had tunnelled up the centre of the trees which were full of mud. Here the primary injury at least was due to the impossibility of the trees getting sufficient play for their roots, when they had developed beyond a certain size. The roots, unable to spread, died, and no doubt the presence of the termites' nests beneath contributed mechanically to this, as will be shown later. The insects finding that the bark and outer wood was dying, quickly attacked it, and having contrived to get at the pith cavity in the centre, removed the dead pith which remained and replaced it with clay.

Such action is what appears to be generally intended when it is said that a tree is killed by termites, the real cause, being perhaps obscure, is overlooked, and the termites who come to remove the dead tissue are credited with the original injury.

But as alluded to above, the position of a nest immediately beneath a small tree may produce considerable injury mechanically. A clump of the red stemmed palm *Cyrtostachys Lakka* was unhealthy and made no growth. The ground around it was ordered to be manured and it was in digging to put in the manure that a termites' nest was found among the roots, on removal of this the tree speedily recovered. Here the injury was mechanical, no part of the tree was bitten or nibbled, but the termites had made a compact hard mass of clay beneath the tree, through which the roots could not force their way, and as their course was mainly vertical the clump was quite unable to make any growth at all.

In larger trees where the roots spread in all directions a termites' nest does no harm at all. In a coffee plantation isolated trees may

now and then be killed in this way, or so far prevented from growing, that they may be condemned as useless, but if many trees perish about the same time and this injury is attributed to termites, the probability is that the diagnosis is wrong, and another cause must be sought.

These termites are usually absent from wet ground, rocky and gravelly spots, and where there is much sand; as these localities are not suitable for their nests. Besides the subterranean termites there are a number which build nests sometimes of considerable size above ground. Nearly all inhabit the forests, and they may play a small part in making mould there, as their nests, often composed of their excreta, break up into a fine soil when the inhabitants have abendoned them, but the number of them is insufficient to be of any great value.

Comparison with the action of Worms.—The differences of the actions of the two animals may be thus summed up:—

The worms eat large quantities of decaying leaves, sticks and other vegetable débris, which are only partially digested and are returned to the soil enriched by their intestinal juices. They also swallow much earth which is eventually passed again on the surface of the soil so that there is a constant turning over of the mould.

The termites eat decaying leaves and timber, etc. They digest them much more perfectly, owing to their more highly organized digestive apparatus. The excreta are hidden away in cells in the ground, and are useless to vegetation till the nest is deserted and partially broken down, and then only if the rain can permeate the ground and wash out the nitrogenous matters. They do not turn over the soil except in taking out the clay in forming the nest, and piling it up on the ground, and this they do on a very small and quite insignificant scale.

Finally, the termites are much more numerous, and have a properly constituted organization adapted for removing the vegetable remains to the cells of the nests in the speediest possible way, while the worms are much slower and fewer in number, and work singly so that they are unable to compete with the termites in procuring vegetable food.

These remarks on termites are only intended to apply to those of the Malay Peninsula. Probably in other countries they may play a part more useful to man, than they do here, where they appear to be distinctly injurious, one need but look at one of the damper, or sandier jungles where the termites do not live to see how rich and deep the soil is, and how the fallen trees decay slowly away into fine chocalate brown mould while in the drier woods on clayey soil wherever the termites abound the mould is thin and scanty.

Very much yet remains to be done in examining into the formation of mould here, the effects of denudation, the chemical analysis of soils, and the action of termites, and this must only be taken as a few facts collected together to form the basis of the study.

A Comparison of the Action of other Grasses with that of Lalang.

The lalang has a creeping under ground stem which pushes its

way everywhere through the stiff clay protected from the great heat of the sun, and deep enough to be uninjured by fire. The turf-grasses on the other hand, which cover the ground in exposed spots, lawns, etc. have almost all creeping stems or stolons which run along the surface of the ground emitting roots at intervals which penetrate the soil. The chief turf plants are the grasses, *Ischoemun muticum* and *ciliatum*, *Cynodon dactylon*, *Paspalum conjugatum*, *Chrysopogon aciculare*; and the small trefoils *Desmodium heterophylium* and *D. triflorum*. If a piece of turf composed of these plants be examined, it will be noticed that there is a distinct layer of brown mould underlying them. The reason for this is that the creeping stems lying flat upon the ground, and producing not an erect stiff foliage but flat horizontal leaves so cover the ground that the rain when it falls strikes and runs off the upper surface of the leaves, and does not touch the mould at all. This surface soil is thus protected from the denuding action of the rain. Furthermore if the turf is thiner and the mould exposed here and there to the heavy rainfall, still the creeping stems so far protect it that it cannot be entirely washed away, and in many places where plants with broad flat leaves such as the "Tutup bumi" *Elephantopus scaber* and *Paspalum conjugatum* grow, small accumulations of humus can be seen beneath the leaves, though the surrounding soil may be bare and hard. The formation of mould here is also aided by the earthworms and ants, which animals cannot, as a rule, exist in lalang fields on acconnt of their heat and dryness, but which are protected from this danger by the turf.

On exposed sloping hillside turf often suffers partly from excessive heat and dryness and still more from the washing down of sand and mud from the higher parts of the hill, which covers the plants and kills them, and the direct force of the rain in very exposed parts where the turf is thin, also has an injurious effect. A striking illustration of the injurious action of the heat and direct force of rain upon turf was shown by an accidental occurrence in the Gardens. Some planks were put upon the grass, where the turf had suffered much from unusual dryness, and had become thin. They were supported on a cross-pole between two others so that the grass beneath was shaded and protected from the direct force of the rain and the excessive heat, of the sun. After a few weeks the grass beneath had grown luxuriantly, and the leaf blades were of a full dark green, while the rest of the turf around was still brown and dry. The soil beneath had a richer brown colour and contained more humus, chiefly I believe because the earthworms had occupied the spot finding it cool and shady. A similar result may often be seen beneath garden seats which have not been moved for some time. Here one can see fresh worm casts, and the ground is cooler and damper than on the surrounding spots.

Turf then, especially if a little protected, improves the soil by inducing the formation of mould which is due to—

(1)—The protection of the decaying vegetation beneath the flat leaves from the excessive rush of rain water;

(2)—By the encouragement of humus producing animals; and

(3)—By the rapid growth of roots which dying and decaying beneath the soil fertilize it and make it rich.

Lalang, on the other hand, does not, as a rule, assist at the formation of mould. It does not protect the surface of the soil from the rush of rain water, nor from the excessive heat of the sun. The humus producers cannot live in so hot and dry a spot, the amount of roots produced by the lalang is also apparently much less in proportion than that of the smaller grasses.

Lalang ground has obtained the worst possible reputation for cultivation, but I believe its value is much underrated. The upper layers are (as shown above) deficient in nitrates, chlorides and carbonates without doubt, but it must be remembered that the tillage here is of the poorest kind. All work is done with the changkol, which does not dig so deep as a spade. Ploughs, except in rice fields in the interior, are not used; so that the soil, except just below the surface, is not exposed to the air or broken up. Frequently too in culture of trees or shrubs such as coffee, cloves, nutmegs, &c., the cultivator puts the manure close round each tree, and never breaks up the soil or manures it between the plants; consequently the roots growing where there is most nourishment, instead of spreading through the soil in every direction, grow round and round the original manured hole, which gets choked up with bent roots, while the surrounding soil is destitute of any. The result is exactly the same as when a plant is grown in a pot too small for it.

That lalang soil can be made productive and quite altered in character by judicious cultivation is evidenced by what can be seen in almost any indigo field. The demand for indigo having largely increased, the Chinese planters are carrying the cultivation from the richer valley soils to the hill slopes of stiff yellow clay, and the contrast between the soil under indigo perhaps not a year planted, and the adjacent untouched lalang soil, is most striking.

The indigo soil is of a rich brown colour and quite friable, while the lalang soil is a stiff hard yellow clay. Certainly the Chinese have put some manure into the soil, and added the indigo refuse, but the chief part of the improvement is certainly due to the breaking up of the soil and the consequent oxidising action of the air; and besides the close compact bushes of indigo, quite shading the ground and preventing the heavy fall of rain from washing out the manure from the soil have contributed much to this result.

Again, a portion of what was formerly called the Military Reserve, was cleared recently and turfed. The land had been formerly under gambier and pepper, and long abandoned had been covered with lalang, scrubby bushes, and ferns. All this was cleared about three years ago and pieces of turf laid down which spread and covered the ground. Before turfing the soil was a bare yellow clay, but now there is a distinct layer of humus beneath the grass. Trees planted therein grow and look healthy, their roots spreading everywhere, while on adjacent land unturfed nothing will grow; trees planted there are weak and die, apparently of starvation. Some of these sickly trees were transplanted to the turfed portion and have speedily recovered and made good growth.

The damage to the trees planted on the exposed banks was certainly mainly caused by loss of nutriment in the drainage water, as it was found that the sand washed down to the foot of the hill after heavy rain from these slopes was strongly fertilizing and was used for manuring other trees. The trees also suffered from exposure of roots caused by the washing away of the soil. Heat seems to seriously injure unshaded roots of certain trees. This can readily be seen where broad roads are made through jungle. If the roads are so broad that the road is not shaded during the hot part of the day nearly all the bigger trees along the roadside soon die.

Fern ground.—In very sandy ground, lalang is usually replaced by bracken, and in many clayey slopes, especially in clearings in and round woods, "Resam" *(Gleichenia linearis)* springs up and thickly covers the ground. Both of these are distinctly beneficial to the soil. Beneath their shade accumulates a thick layer of broken stems and fronds, while the ground is filled with decayed roots and rhizomes, forming a thick rich deposit of humus. As a rule also termites are absent. Resam, however, prevents by its close growth the development of seedlings of trees and shrubs to a very large extent, so that this ground may remain for a long period unforested, and in many places the fern may even destroy trees which grow among it. This is chiefly done by the climbing Gleichenia which climbs to the tops of the smaller trees and bushes and covers them.

Fern then when close grown prevents denudation of moulds and aids in forming a fresh supply. It is, however, rather troublesome to eradicate when the ground is wanted for cultivation, but is not nearly as bad as lalang.

Fallowing and Rotation of Crops.

In agriculture in cool climates where herbaceous plants are usually grown, rotation of crops is considered of vital importance, and carefully and scientifically arranged for. But in countries where the crops are derived from slow-growing trees and shrubs, and where expensive machinery is required for each different kind of crop, the change of crops is usually difficult or impossible, little can be done in many cases except to put back on the soil as much of the crop refuse as possible and to supply the remaining deficit by manure.

But quick-growing crops such as indigo, rami, pine-apples and tapioca could certainly be alternated, and indeed some amount of rotation does take place, not indeed for scientific reasons, but either because one crop fails and the cultivator finding it no longer pays starts a fresh one, or because owing to a demand for some special crop all immediately commence to plant that, abandoning the cultivation of the previous kind.

Fallowing, that is to say, resting the ground in order that the nitrates may again be formed in the soil, is reduced here to abandoning the land to the growth of lalang, which, as has been shown, does not increase the nitrates, but rather diminishes what remains. It would be far better to encourage the growth of almost any other plant, or to plant fallow crops, of dal, or some such plant for a year or two, and then dig in the whole crop to make additional humus.

Paper-stuff.

Lalang.—The lalang is chiefly used here for thatching huts, and for burning with clay to make burnt earth for manuring field-crops. The Chinese too collect the rhizomes and export them to China where they are used in native medicine. They contain a certain amount of sugar, and at one time a kind of beer was made from them in Singapore. The wild pigs are very fond of lalang shoots and rhizomes, but cattle do not care for the leaves, as they are rough and hard. The silky plumes are used by the natives for stuffing pillows.

The most likely use for the plant to prove valuable is that of paper-making. The supplies of paper stuff throughout the world are considerably less than the demand, and an abundant plant which would make fairly good paper would prove of considerable value. In 1881, Mr. John Fisher filed a specification in Singapore, for utilizing the fibre of lalang and citronella grass by boiling it under pressure with caustic soda, and making cordage and paper stuff from it, but no further work was done in this way. Similar experiments were made at the Botanic Gardens this year (1894), with good results. The grass was dried in the sun and cut up into lengths two or three inches and put in a stone jar, which was then filled up with water, and caustic soda added. The lid of the jar was then tied down and it was put in an iron drum, which was filled with water and heated. It was thus boiled for some hours.

The pulp was then washed and beaten with wooden hammers, or in a rice-pounder, till the fibres were broken up and then spread out in the form of sheets and dried. The result was a fine yellow half-stuff, quite homogeneous, and tolerably firm and bibulous. Specimens were sent to Kew Gardens for report, which has, however, not come yet to hand. Should it be found successful, this half-stuff might be made on a large scale, with better means of boiling and pounding, and it could be made up in sheets and baled for export.

It could probably hardly compete with the highly valued Babul grass of India, which is tougher and more fibrous, but it may very well supplement this, as the lalang often grows clean without the admixture of any other weeds, the collecting of it would be very easy and inexpensive, and as it is of so rapid a growth, a comparatively small acreage would furnish a permanent supply.

Ginger Stems.

In many parts of the Peninsula are large thickets of wild gingers (*Scitamineæ*) belonging to the genus *Amomum*. The larger kinds *Amomum megalocheilus, A. imperialis &c.*, throw up leafy stems from six to fifteen feet or more tall, and about an inch through, the flowers being produced either on short stems near the ground, often so short that the flowers which are usually bright red hardly appear above the soil. These plants are known to the Malays as Tepus.

The leafy stems are very fibrous and could certainly be used for making paper stuff. The stems should be cut into lengths of about

three feet and divested of the leaves and outer sheath, and then beaten with a wooden mallet and washed, till they are reduced to a bundle of strong fibres. They are then cut up into lengths of two or three inches and boiled, as directed for lalang paper stuff, with caustic soda.

The pulp requires more beating than lalang, as the fibres are stiffer and harder. It makes a very strong pasteboard, and would doubtless fetch a good price as half-stuff.

A strong yellow fibre suitable for cordage can also be obtained from the stems by boiling in plain water, and beating out with a mallet.

Planters who have much of these plants near their plantations might do well to have the stems cut and beaten out and washed, and sent in bales to the paper mills, where it would doubtless fetch a good price.

Betel-nut Sheaths.

The sheaths which enwrap the flower panicle of the betel-nut when cut up into small pieces and boiled with caustic soda, and pounded, also make a very strong paper stuff. These, however, fetch a good price for wrapping dried fish, &c. in, and are also said to be used by the Chinese for making shoes, so that the supply is not much larger than the demand for these purposes.

SHORT NOTES.

Indigo Cultivation in Singapore.

The cultivation of indigo in Singapore seems to be largely increasing, and much interest is being taken in it by others than Chinese. Everywhere one now sees old lalang fields being cleared and planted up, and we may hope to see the cultivation taken up for export ere long. In many places it is replacing pine-apples, of which lately an excessive supply has been produced, and the market has this year been overstocked, pines selling at four for a cent. A great field is open for a good and cheap pine-apple fibre-cleaning process or machine, as the supply of leaf of very fair to large size is practically unlimited.

Gambir and pepper cultivations seem to be dwindling away in Singapore; the low price of the latter at present has had much to do with the falling off of the pepper cultivation.

Copper Sulphate as a Timber Preservative.

Immersing timber in a solution of copper sulphate to protect it from the ravages of termites and dry rot, was tried in India as early as 1847, the timber being boiled under pressure. This entailed, however, expensive machinery, and it was shown that where there was a considerable amount of moisture the timber eventually perished. I made some experiments by simply immersing the wood in a strong solution of copper, and found it to have a distinctly pre-

servative effect. Of two exactly similar pieces of Serayah wood, one was soaked in the solution for three days, and both were left for nine months in the jungle among the dead leaves, in a very wet place swarming with termites. At the end of that period the untreated piece had utterly disappeared, while that which had been soaked in the liquid, was perfectly sound, except that at one spot the termites had cut a short groove, which they had afterwards apparently abandoned. As the Serayah is a soft wood the test was a pretty severe one, and seems to show that merely immersing the wood in the solution will enable it to resist termites and fungus for a considerable time. Posts and poles for outdoor work might well be soaked in a tank of copper sulphate solution before using.

Vanilla.

Some very strong plants grown on an oil palm in the Botanical Gardens, flowered well this year during the unusual hot and dry spell, but only one flower set fruit, and that was spoilt by rain. It is evident that this climate is unsuited for Vanilla, which requires a dry season to ripen its fruits.

We have one wild species of Vanilla in the Peninsula, *V. Griffithii* Rchb. f., which fruits heavily in January when the plant is old enough, but, like most of the species, the fruit, which in shape resembles a small banana and is sweet and eatable, contains no vanilla and is therefore useless.

Ipecacuanha.

The Ipecacuanha of the Pengerang Estate appears to maintain its high reputation if we may judge by the home market reports, where when good quality Cartagena was at 4/6*d.* per lb. and fair stout Brazilian at 5/9*d.*, the owner refused 6/- per lb. for the Johor root.